NOVA/BEAMLET/NIF UPDATES JANUARY–MARCH 1996

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Nova Operations

During this quarter, Nova Operations fired a total of 309 system shots resulting in 319 experiments. These experiments were distributed among inertial confinement fusion (ICF) experiments, Defense Sciences experiments, X-Ray Laser experiments, Laser Sciences, and facility maintenance shots.

As planned, we held a design review to discuss upgrading Nova to include spatial beam smoothing capability on all 10 beamlines. In support of this upgrade, a prototype phase plate and debris shield holder was fabricated, installed, and tested on the 10-beam target chamber. A prototype of the kinoform phase plate (KPP) was also fabricated and used on several target experiments. The KPP produces a smoother focus spot on target than the present phase plate and is planned to be used on the National Ignition Facility (NIF). Design modifications to the optical system for the preamplifier beamline modifications were completed, and the orders were placed. The substrates and finishing required for the KPPs were also ordered. Experiments using beam smoothing on all 10 beamlines are planned for the fourth quarter.

In support of the ongoing Petawatt project, we achieved the following tasks:

- Completed the vacuum compressor chamber and vacuum leak tested the system.
- Installed and aligned primary optical components required to demonstrate pulse compression (mirrors, gratings, and diagnostic telescope).
- Activated the basic diagnostics required to measure pulse width and bandwidth.
- Installed and aligned the new injection beamline from the Petawatt Master Oscillator Room to the Nova laser.
- Took several shots at low energy and with the compressor at atmospheric pressure to check the initial system performance.
- Obtained a low-energy compressed pulse of ~650 ps.
- Scheduled full-power shots to demonstrate Petawatt performance to be done during the third quarter .

We also developed a design for a small target chamber to be installed between the compressor and 10-beam target chamber to allow using the Petawatt beam for simple target experiments that do not require the full diagnostic capability of the 10-beam chamber. This configuration would provide more flexibility and would allow the Nova system to support Petawatt target shots without impacting the 10-beam target chamber. A final design review for the mini-chamber is scheduled for the third quarter.

Several modifications were made to the 100-TW system to improve system reliability and performance:

- Reviewed the design and purchased the hardware for a closed loop alignment system to improve system shot-to-shot stability and repeatability. Installation is planned for the third quarter.
- Installed a graphical user interface to the control system to allow the operators to configure the system more efficiently.
- Relocated the power conditioning hardware outside the oscillator room, due to excessive electrical noise problems.
- Ordered several spare parts to reduce system downtime during maintenance and repair.

To reduce film handling, processing, and digitizing, we use charge-coupled-device (CCD) cameras. We modified one of the six-inch-manipulator (SIM) based diagnostics used on the 10-beam target chamber to replace its film back with a CCD camera. We plan to modify an additional SIM diagnostic with a CCD camera by the end of FY 1996.

Beamlet

During the quarter, experiments continued on Beamlet to validate the laser physics foundations for the NIF design and addressed the following issues:

- Controlling the growth of near-field amplitude modulation in the 1.06-μm laser amplifier.
- Determining the source terms for scattered light, and its nonlinear amplification at high power in the 1.06-μm laser.
- Performing large-area damage tests and online damage conditioning of KDP.
- Performing online conditioning tests of high-fluence 1ω reflective coatings.

All of these experiments are part of long-term continuing campaigns that will include two or more experimental series.

The shots to study near-field beam modulation were in support of a working group studying the power and energy limits imposed on the output of the 1.06-μm laser by the nonlinear growth of optical noise that originates from imperfections in the beam optics. In this series, we studied the increase in near-field modulation at several planes beyond the booster amplifier output as the B-integral increased and as a function of pinhole size in the cavity and transport spatial filters. With 200-ps pulses, we used pinholes as small as 130 μrad in the cavity spatial filter and 100 μrad in the transport filter. As expected, and in contradiction to the observation made on Nova, the smaller pinholes produced smoother beams. We produced pulses with B-integrals up to, and exceeding, the NIF requirement with well controlled modulation and no evidence of filamentation. We have not yet tested small pinholes with long, high-energy pulses required for NIF; this will be an issue in future experiments.

We activated a new dark-field imaging output diagnostic to provide sensitive measurements of small-angle scattered light at the Beamlet 1ω output. This diagnostic improves our ability to accurately measure optical noise within the band between 33 and 800 μrad half angle and will allow us to quantify noise amplification that results from nonlinear phase retardation effects. We fired low- and high-power shots with various cavity pinhole sizes and dark field image blocks in the initial series to measure the noise power.

In support of the NIF materials development group, we performed large-area damage tests on KDP samples. The tests determined an unconditioned damage threshold of 8 J/cm^2 and demonstrated that large area online conditioning of KDP in a vacuum environment is effective.

We installed a set of four high-damage-threshold 1ω mirrors between the output transport spatial filter and the frequency converter, simulating the NIF transport mirror system, to investigate the feasibility of online conditioning. The alternative offline raster scan conditioning is time consuming and costly; if online conditioning can be demonstrated, it provides a more cost-effective and efficient substitute. Two of the four mirrors were offline conditioned and the other two were to be online conditioned. Anomalously high amplitude modulation (3 to 1, peak/average) at the output of Beamlet occurred on two shots early in this series. In each case, both of the unconditioned mirrors were damaged and the tests had to be terminated. The offline conditioned mirrors were more robust—only one damaged on one of the shots. We will renew our attempt to demonstrate online conditioning later in the year when additional mirrors become available.

We also removed two cavity amplifier slabs and replaced them with recently refinished slabs. During the disassembly, we noticed some degradation of amplifier components and are investigating the cause. The slabs removed had been finished using unoptimized small-tool polishing techniques. We will use high-resolution interferometry to characterize these slabs to determine if refinishing is necessary, and the laser modeling group will use the data in propagation modeling.

National Ignition Facility

During the quarter, we began Title I design, which was initially affected by delays in the Project FY 1996 total estimated cost funding. To support Title I design efforts, we updated the technical basis of the design, increased Project staff to the planned levels, developed key Project controls and documentation, and developed support infrastructure required to support the design support. The NIF Project activities are now proceeding as planned.

The technical basis of the design was updated through a formal technical review process that included the following:

- Completing an Advanced Conceptual Design (ACD) review in February, including technical and financial impacts of user requirements.
- Updating the Primary Criteria/Functional Requirements.
- Updating and improving the System Design Requirements.
- Developing optics assembly capability requirements.
- Updating the laser system design/performance baseline.

Key Project controls and reporting procedures were put in place, including the following:

- Implementing the *NIF Project Control Manual*, the *Configuration Management Plan*, and the DOE-approved *Quality Assurance Program Plan*, and providing training on key procedures and configuration management.
- Installing the commercial NIF Sherpa Product Data Management system that provides a project-wide centralized document engineering drawing, and configuration-control capability.

- Establishing cost account plans and authorizations for each work breakdown structure element.
- Developing a detailed Title I design schedule.
- Establishing regular Title I baseline costs and schedule reviews to track progress.
- Preparing and distributing monthly and quarterly progress reports.

To reflect the national scope of the NIF Project, the NIF participating Laboratories agreed to, and implemented, the following expanded workscopes:

- Sandia National Laboratories (SNL) expanded the workscope includes conventional facilities management, construction management, mechanical systems integration, target area structure analysis, the target experimental data acquisition system, and diagnostic system integration. The SNL team includes engineering design staff at Sandia—Livermore, California.
- The expanded Los Alamos National Laboratory workscope includes structural support for key opto-mechanical assemblies (cavity mirror, Pockels cell polarizer, and extra-cavity turning mirror) and target area robotics.
- The Laboratory for Laser Energetics at the University of Rochester expanded workscope includes large-aperture polarizer coatings and exploration of production capabilities for high-performance, large-aperture optics coatings.

All major contracts for the Title I design have been decided including the architecture/engineering contract for the Laser and Target Area Building (LTAB), contracted to Parsons; the Optics Assembly Building (OAB), contracted to A. C. Martin; the Construction Manager, contracted to Sverdrup; Engineering Design Services contracted to Northrup/Grumman, TRW, Physics International, and SAIC; and Management Services, contracted to XEC and LRL.

The laser system design was updated through an optimization analysis performed by a NIF Project and ICF Core Science and Technology team. This update resulted in a NIF laser configuration that is improved from the Conceptual Design Review (CDR) version. The design (the 11-0-7 configuration) has an 11-slab main amplifier, no switch amplifier, and a 7-slab boost amplifier that meets the NIF 1.8-MJ and 500-TW on-target technical requirements. This design is comparable in cost to the CDR design within the available resolution, and it meets the NIF functional requirements at lower risk. Design improvements include:

- A lower filamentation risk due to lower B-integral (1.8 vs 2.1).
- Greater similarity to the Beamlet 11-0-5 configuration, thereby reducing development costs and risks.
- Elimination of switch amplifier magnetic field interactions with the adjacent plasma electrode Pockels cell.
- Fewer laser support structures, and a shorter LTAB length.

Significant design progress has been made in all areas. Following extensive functionality and cost analysis of various building layouts and configurations, Title I design of the LTAB building began. A general arrangement of the facility was developed and is now in configuration control, and laser layouts have been incorporated into the overall facility layout (Fig. 1). Locating the LTAB and OAB at the preferred Livermore site has also been completed, which minimizes site development costs.

(a) LTAB ground level view

(b) LTAB composite view

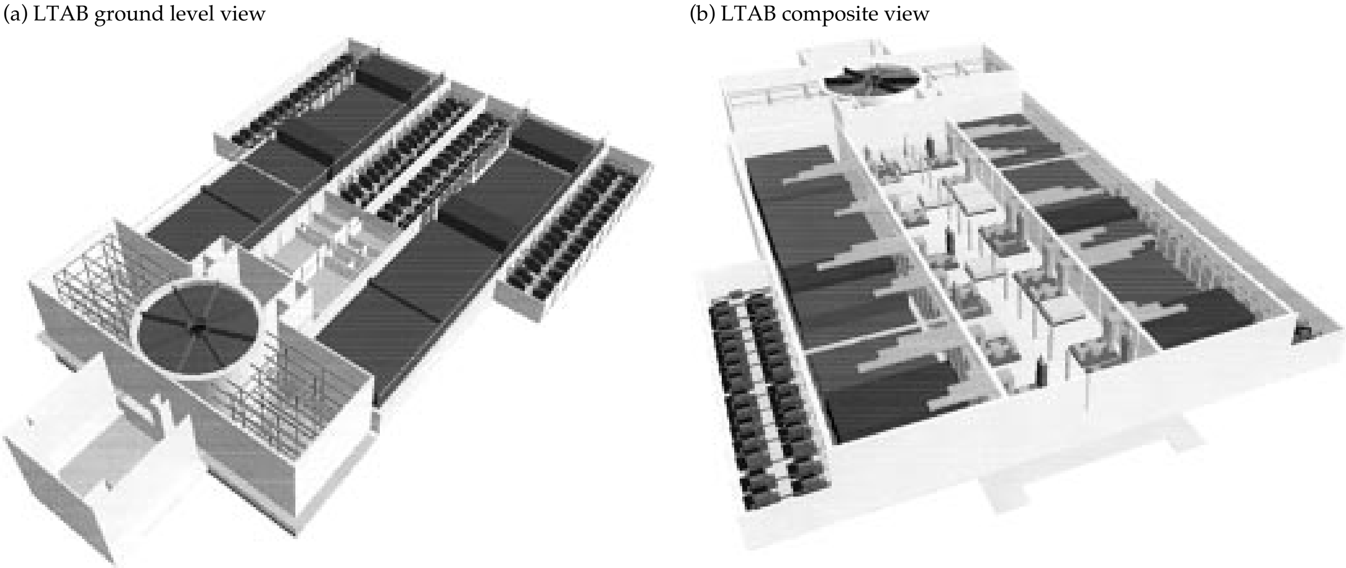

FIGURE 1. 3-D CAD models for the NIF Laser and Target Area Building (LTAB). (40-00-0496-0847pb01)

In the laser area, we completed the design analysis to determine pumping uniformity of the end slabs in the amplifier. The analysis shows that the required uniformity is met without the addition of end lamps. Design iterations, based on finite-element analysis on all the laser bay support structures, have been completed. These structures were re-engineered from the CDR to minimize construction costs and to improve their performance in terms of increasing the first resonant frequency a significant 20%. Designs for bottom loading line replaceable units (such as amplifier cassettes) into the beamline have been developed.

We completed the beamline optical component layouts within the LTAB. The design includes first-order raytrace to establish the approximate spacing between the optical components followed by the Code V layouts that provide detailed locations of the optical components. The optical sizes of the main laser components have been determined and clear aperture analysis is under way.

The NIF is a part of the Stockpile Stewardship and Management (SSM) Programmatic Environmental Inpact Statement (PEIS). The SSM PEIS reaffirms the Secretary of Energy's statement during Key Decision One that LLNL is the preferred site for the NIF. In support of the PEIS, writeups, supporting analysis, and reviews have been provided to the DOE, as well as a Preliminary Safety Analysis statement draft document. A final site selection will occur after public review of the SSM PEIS and a formal Record of Decision by the Secretary in September 1996.

During the third quarter, the mid-Title I design review will be conducted, and we will continue toward completion of the conventional facilities Title I design in September and special equipment design in October, as scheduled.